NON-PUBLIC?: N
ACCESSION #: 8911070016
LICENSEE EVENT REPORT (LER)

FACILITY NAME: Duane Arnold Energy Center (DAEC) PAGE: 1 OF 7

DOCKET NUMBER: 05000331

TITLE: Turbine Control Valve Fast Closure Trip Results in Reactor Scram While Performing Testing
EVENT DATE: 08/26/89 LER #: 89-011-01 REPORT DATE: 10/25/89

OTHER FACILITIES INVOLVED: None DOCKET NO: 05000

OPERATING MODE: N POWER LEVEL: 100

THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR SECTION:
50.73(a)(2)(iv)

LICENSEE CONTACT FOR THIS LER:
NAME: Brian K. Smith, Technical Support Specialist
TELEPHONE: 319-851-7456

COMPONENT FAILURE DESCRIPTION:
CAUSE: X SYSTEM: EL COMPONENT: XCT MANUFACTURER: GO80
B EB CL GO80
REPORTABLE NPRDS: N
Y
SUPPLEMENTAL REPORT EXPECTED: NO

ABSTRACT:

On August 26, 1989, at 1642 hours, with the plant operating at 100% power, Operations Procedure, "Power/Load Unbalance and Relay Circuits Test" was in progress. This test is performed for continued reliable operation of the main turbine. Contrary to what was expected, a trip of the main turbine control valves and subsequent reactor scram occurred at 1643 hours. Subsequent detailed investigations identified bridging of a mercury-wetted relay in the power/load unbalance circuitry as the most probable root cause for the turbine trip and subsequent reactor scram. Approximately five minutes following the scram, problems were encountered on the "B" essential and non-essential busses. Subsequent investigation revealed the root cause to be a failed trip coil on an associated breaker.

The plant was brought to a normal, safe shutdown condition and the appropriate notifications were made. There was no effect on the safe operation of the pla
t.

END OF ABSTRACT

I. DESCRIPTION:

On August 26, 1989, the reactor was at 100% power, producing 1655 MWTH. At 1642 hours, Operations Department Procedure (OP), "Power/Load Unbalance and Relay Circuits Test" was in progress. This OP is performed weekly to comply with a General Electric recommendation for continued reliable operation of the main turbine (EIIS System Code TA). Satisfactory performance of the OP will ensure the operability of the power/load unbalance circuitry (EIIS System Code TG) that protects the main turbine against rapid acceleration during power operation when a loss of load (the main generator (EIIS System Code TB)) occurs. The OP consists of two steps, both performed at a Control Room backpanel. Step one calls for depressing the "Power/Load Unbalance - Push to Test" pushbutton and verifying that the pushbutton's yellow light comes on. This simulates an unbalance condition and the power/load unbalance circuitry functions causing the test pushbutton's yellow light to come on. This effectively tests the entire protective circuitry with the exception of energizing the turbine trip relays. (The test pushbutton's yellow light will come on when a power/load unbalance exists, regardless of whether the test pushbutton has been pushed or a genuine unbalance condition occurs.) Step two of the OP calls for releasing the test pushbutton and verifying that the yellow light goes off. This removes the power/load unbalance circuitry from the test mode and allows the normal inputs to be reapplied, but a time delay allows approximately five seconds prior to placing the turbine trip relays back into operation.

Step one of the OP was successfully performed; the "Power/Load Unbalance - Push to Test" pushbutton was depressed and the yellow light came on. This successfully verified that the power/load unbalance circuitry was functioning properly. Step two of the OP was then performed and the test pushbutton was released. Contrary to what was expected, the yellow light remained on. The operator immediately realized that this was incorrect. While referring to the OP and attempting to determine why the yellow light remained on, the power/load unbalance circuitry time delay timed-out and caused a trip of the main turbine control valves.

A full Reactor Protection System (RPS) (EIIS System Code JC) trip

occurred resulting in a full reactor scram at 1643 hours (Turbine Control Valve fast closure with the reactor at greater than 30% power.) As expected, both recirculation pumps (EIIS System Code AD) tripped due to the Turbine Control Valve fast closure trip. All control rods fully inserted. Reactor level immediately began to drop, due to void collapse, to a low of approximately 160 inches. Primary Containment Isolation System (PCIS) (EIIS System Code JM) Group II through V isolations occurred as designed when reactor vessel water level dropped below 170 inches. Reactor vessel pressure rose to a high of approximately 1120 psig. Three safety relief valves (EIIS System Code

SB), two being Low-Low set valves, lifted a single time to reduce reactor pressure. At 1645 hours, the RPS scram logic was reset.

The Reactor Feed Pumps (EIIS System Code SJ) continued to operate and reactor vessel water level rose within 30 to 60 seconds to near the 211 inch high level trip setpoint. Both feed pumps were manually tripped. Reactor pressure stabilized at approximately 960 psig via automatic operation of the turbine bypass valves (EIIS System Code JI).

At 1647 hours, approximately five minutes after the initial reactor scram, the generator reverse power annunciator was received as expected following a turbine trip event. However, this was followed by a partial loss of lighting (EIIS System Code FF) in the Control Room due to a loss of the "B" essential bus (EIIS System Code EB). The "B" Emergency Diesel Generator (EIIS System Code EK) started. It quickly assumed loads on the "B" essential bus which restored normal control room lighting. The "B" non-essential bus (EIIS System Code EB) was noted as being deenergized, indicating that it had not successfully transferred as designed to its alternate supply. A second full RPS actuation and a PCIS half Group I isolation also occurred. Immediately, the Operations Shift Supervisor dispatched an operator to the switchgear rooms to investigate the affected "B" non-essential bus supply breakers. Concurrently, the "B" RPS logic actuation and PCIS half Group I isolation were determined to have occurred due to the loss of power to the "B" RPS M-G set (EIIS System Code ED) when the "B" essential bus was lost. The "B" RPS power supply was manually transferred to the alternate power source (powered directly off of the "A" essential bus (EIIS System Code EB)). The "A" RPS logic actuation appears to have been caused by the plant electrical bus transients. The RPS trip was reset at 1710 hours.

Investigation into the improper indication of the two breakers revealed that the normal supply breaker was still closed, but that some damage had occurred to it, and that the alternate supply breaker was tripped. The

automatic transfer of power for the "B" non-essential bus had not occurred as designed. Normally, when a turbine trip occurs, the "B" non-essential bus is transferred to its alternate power source. The alternate supply breaker closes, then the normal supply breaker opens (a make-before-break transfer). In this case, the alternate supply breaker closed; however, the normal supply breaker's trip coil failed, thus preventing it from opening. Almost immediately, an overcurrent condition occurred which caused the alternate supply breaker to trip and deenergize the "B" non-essential bus and also caused the degraded voltage protection circuit to function which load shed the "B" essential bus and started the "B" Emergency Diesel Generator.

Due to the difficulties with the non-essential busses, Operations personnel elected to manually initiate the High Pressure Coolant Injection (HPCI) system (EIIS System Code BJ) at 1652 hours to control reactor vessel water level. At 1710 hours, Operations personnel

manually started the Reactor Core Isolation Cooling (RCIC) system (EIIS System Code BN), to provide for finer level control, and secured the HPCI system.

At 1722 hours, the "B" essential bus was transferred to its normal power source from the "B" Emergency Diesel Generator and the generator was unloaded.

The "A" Feed Pump was started satisfactorily at 1736 hours. The RCIC System and the "B" Emergency Diesel Generator were secured and the PCIS Groups II, IV, V, and the "A" Group III isolations were reset. At 2204 hours the PCIS "B" Group III isolation was reset.

II. CAUSE OF EVENT:

Investigation into the cause for the main turbine trip was initiated by troubleshooting the power/load unbalance circuitry. This initial troubleshooting identified no failed or inoperable components. A failure of one of the three main generator current transformers (EIIS System Code EL) that input into the power/load unbalance circuitry had been identified by plant personnel on July 10, 1989. Each of these current transformers sense the output current of one phase of the main generator to input into both the Plant Process Computer, for providing indication of generator power (megawatts), and the power/load unbalance circuitry. The main turbine intermediate stage (crossover) pressure (power) is compared to the summed value of the three current transformer inputs (load) to provide a power/load differential value (ideally 0%). This

initial troubleshooting also identified that the power/load unbalance circuitry is much more sensitive to inputs with the one current transformer signal removed. No failed components and/or instruments were identified in troubleshooting and the power/load unbalance circuitry functioned properly.

The discussions in July between Iowa Electric personnel and General Electric concerning the failed current transformer resolved that continued plant operation was permissible; that the failure would not affect the weekly performance of the OP or power operation. However, these discussions did not address the increased sensitivity of the power/load unbalance circuitry. The power/load unbalance circuitry has two permissives, referred to herein as "differential" and "rate-plus-differential", both of which must be satisfied for the circuitry to initiate a trip. The differential permissive requires that a power/load differential greater than 40% occur. The rate-plus-differential permissive additionally requires that the greater than 40% power/load differential occur within a short amount of time (a fast rate-of-change time constant). Once tripped, the rate-plus-differential permissive "seals-in". The power/load unbalance circuitry remains tripped until the high power/load differential permissive clears. The OP was successfully performed several times prior to the August 26 event. Investigation revealed

that on August 26 during performance of the OP, a power/load unbalance circuit trip was still present at the conclusion of the OP. The trip initially appeared to be due to a combination of the failed current transformer and increased sensitivity characteristics of the power/load unbalance circuitry. However, further investigation has identified that the most probable root cause for the power/load unbalance circuitry tripping the turbine was due to bridging of the mercury-wetted differential relay.

Initial discussions with General Electric focused on the failed current transformer as the cause of the inadvertent turbine trip. Subsequently, General Electric provided a representative to aide in root cause verification on site. Significant troubleshooting was performed that involved circuit testing, calibration checks of associated instrumentation, and test simulations, etc. that provided substantial data for analysis. This troubleshooting ultimately resulted in identifying the need for several minor adjustments to the power/load unbalance circuitry to fine tune its operation. It also determined that the most likely cause for the inadvertent trip of the power/load unbalance circuitry was due to bridging of the power/load unbalance

differential relay. This bridging would prevent this trip relay from resetting until it was cycled (tripped and reset) again. Further troubleshooting and testing verified that this relay functioned as designed and would not repeat this bridging again. See Section V for more details.

Later that same day, plant maintenance electricians investigated both of the affected breakers. The normal supply breaker was inspected and the failed trip coil easily identified by blackened areas around the cover. Following a thorough inspection and cleaning of the breaker cubicle, and an inspection and operational verification of a spare breaker, the spare breaker was installed and the "B" non-essential bus reenergized on August 27 at 1616 hours. The alternate supply breaker and its associated cubicle were also inspected and verified with no abnormalities found. The original breaker's trip c-oil was removed for root cause investigation of its failure, a new trip coil installed, and breaker operation verified. Further investigation into the root cause for the failure of the trip coil revealed that the coil's slug had become cocked slightly, preventing the coil from energizing and tripping the breaker. However, because of the applied trip signal, the trip coil repeatedly attempted to trip until it failed/burned-up. The root cause of the trip coil failure has been determined to be age-related wear. This was the original trip coil.

III.
ANALYSIS OF EVENT:

A turbine trip at 100% power is an analyzed event. The RPS and all other plant systems operated appropriately. The difficulties in essential and non-essential busses power hampered the event to some extent, but did not jeopardize a safe shutdown. Operations personnel

performed their duties professionally. During the event, the reactor remained in a stable condition with cooldown proceeding to facilitate restarting of the recirculation pumps. The "B" non-essential bus remained deenergized pending further investigation into the problems with its supply breakers. Once resolved, the bus was reenergized and loads were aligned properly. There was no adverse effect on the safe operation of the plant.

IV. CORRECTIVE ACTIONS:

Several long-term corrective actions have been initiated as a result of the event:

1. The "Power/Load Unbalance - Push to Test" pushbutton was caution tagged to prevent performance of the OP until the failed current transformer was replaced on September 19, 1989.

2. The Operations Supervisor reviewed this event and the other recommended turbine protection tests with Engineering, Maintenance, and General Electric personnel. There are currently 11 separate OPs performed for turbine protection testing. Including the "Power/Load Unbalance and Relay Circuits" test, there were three OPs identified as requiring additional precautions for testing due to this event review. Engineering actions to address these two additional OPs have been initiated and are under review.

3. A design change to the power/load unbalance circuitry was installed to prevent inadvertent turbine trips while testing. A safety evaluation was performed and verified that this change in no way effects normal operation of the circuitry or precludes its protective function.

4. Actions have been taken to procure replacement circuit cards for the Electro-Hydraulic Control System (EIIS System Code TG) to have available for use/replacement on site.

5. A preventive maintenance program to perform testing of the power/load unbalance circuitry each outage has been established.

6. Operations training has been assigned to review this event in upcoming operator requalification sessions, ensuring that all personnel are aware of the operation of the power/load unbalance circuitry.

7. A preventive maintenance program to inspect/replace the trip coils in other 4160 Volt breakers has been initiated.

8. A Scram Reduction Committee has recently been established which will work to identify and recommend changes which will effectively reduce the potential for reactor scrams.

V. ADDITIONAL INFORMATION:

1. The failed generator current transformer was an original installed component manufactured by General Electric. The failed trip coil was an original installed component manufactured by General Electric

on a 4160 VAC MagnaBlast breaker. The mercury-wetted relay is a circuit board mounted component for General Electric Electro-Hydraulic Control System circuit cards.

2. No similar events have occurred.

3. During a normal test, when the "Power/Load Unbalance - Push to Test" pushbutton is depressed, the turbine trip relays are disengaged from the power/load unbalance circuitry and the power/load differential and rate-plus-differential permissive sensing logics are grounded. This simulates a genuine unbalance condition and the test pushbutton's yellow light will light. The rate-plus-differential permissive seals-in. When the test pushbutton is released, the logic grounds are removed and the normal inputs will be reapplied which will allow the differential permissive to reset and thereby reset the power/load unbalance circuitry. After a short time delay, the circuitry again provides an input to the trip relays.

This circuit, as well as other turbine protection circuits in the Electro-Hydraulic Control System, utilize normally open mercury-wetted relays. These are considered to be highly reliable in this application. However, the General Electric representative pointed out instances where normally open General Electric mercury-wetted relays have bridged and initially failed to reset. In this event, troubleshooting could not get the power/load differential relay to repeat this bridging; therefore, it was determined to be satisfactory to leave in use. It is important to note that the bridging prevented the differential relay from resetting, but did not effect its ability to trip in any way.

This event is being report pursuant to 10 CFR 50.73(a)(2)(iv).

ATTACHMENT 1 TO 891107016 PAGE 1 OF 1

Iowa Electric Light and Power Company
October 25, 1989
DAEC-89-0646

Mr. A. Bert Davis
Regional Administrator
Region III
U. S. Nuclear Regulatory Commission
799 Roosevelt Road
Glen Ellyn, IL 60137

Subject: Duane Arnold Energy Center

Docket No: 50-331
Op. License DPR-49
Licensee Event Report #89-011, Rev 1

Gentlemen:

In accordance with 10 CFR 50.73 please find attached a copy of the subject revised Licensee Event Report.

Very truly yours,

Rick L. Hannen
Plant Superintendent - Nuclear

RLH/BKS/gt

cc: Director of Nuclear Reactor Regulation
Document Control Desk
U.S. Nuclear Regulatory Commission
Mail Station PI-137
Washington, D. C. 20555

NRC Resident Inspector - DAEC

File A-118a

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